SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS, JANUARY, 1932

By Herbert H. Kimball

At Washington, D. C., Madison, Wis., and Lincoln, Nebr., the Weather Bureau has installed Marvin pyrheliometers with which, when the sky is free from clouds, measurements of the intensity of direct solar radiation at normal incidence are obtained.

At Washington the measurements are made on the campus of the American University about 5½ miles northwest of the United States Capitol, 3 miles northwest of the central office of the Weather Bureau, and 1½ miles northwest of the United States Naval Observatory. There are no manufacturing establishments within a radius of about 3 miles, but the suburb about the university is rapidly building up, principally with detached houses. The pyrheliometer is exposed on a shelf outside a window, in the morning on the southeast side of the building and in the afternoon on the southwest side. At times, with southeast or east winds, city smoke is brought over the university.

At Madison the pyrheliometer is installed in North Hall, University of Wisconsin, and exposed on a shelf outside a window facing east in the morning and west in the afternoon. North Hall is on a bluff in the upper campus, a short distance from the south shore of Lake Mendota. Most of the manufacturing plants are in the eastern part of the city, but railroad tracks and the heating plant of the university are to the southwest. With a northwest wind the air is free from smoke, but with the wind from other directions considerable smoke is brought over the campus.

At Lincoln the pyrheliometer is exposed in the experiment station building, on the farm campus, State University Farm. It is 2½ miles northeast of the center of the business section of the city, but there is some smoke from buildings on the farm campus and from railroads and shops not far to the north. Under certain conditions the city smoke cloud covers the farm campus, but with a west to northwest wind the atmosphere is very clear. When observing, the pyrheliometer is exposed on a shelf outside a south dormer window.

Besides these measurements of the intensity of direct solar radiation at normal incidence, continuous records of the intensity of the solar radiation received on a horizontal surface, including that received diffusely from the sky, are obtained at eight Weather Bureau stations, and at five additional stations, through cooperation with the Bureau of Entomology, United States Department of Agriculture (Twin Falls, Idaho), with the Scripps Institution of Oceanography (La Jolla, Calif.), and with the Universities of Florida (Gainesville), Miami (Belle Isle), and Tulane (New Orleans).

For descriptions of these various pyrheliometers and registers the reader is referred to Weather Bureau Circular Q, Pyrheliometers and Pyrhelimetric Measurements, Washington, 1931.

The pyrheliometers for recording the total radiation are generally exposed on the roof of a building where they have free exposure to the entire hemispherical vault of the sky. At Chicago the exposure is on the tower of Rosenwald Hall, University of Chicago, and at New York on the tower of the New York Meteorological Observatory in Central Park. At both these stations there is considerable depletion of the radiation by smoke. This is also true, but to a less degree, at Madison and Lincoln. During 1931 the pyrheliometer at Tulane University was considerably shaded by trees and surrounding buildings. With the first of the present year it was moved to the roof of the medical building, where it has an excellent exposure.

All pyrheliometers from which records are summarized in Tables 1 and 2 have been standardized by comparison with Marven pyrheliometer No. 3, except the Callendar instrument at Miami, which has a standardization certificate furnished by the English manufacturer. Quite probably this certificate gives radiation intensities on the Ångström scale, which is 3.5 per cent lower than the Smithsonian scale, with which Marvin No. 3 is made to agree by frequent comparisons.

The coordinates of the different stations and the instruments employed are as follows:

Stations	Instruments	Registers	Latitude	Longitude	Altitude
			° ′	° ′	*Feet*
Washington, D. C.	{Marvin		38 56 N.	77 05 W.	397
	{Eppley	Engelhard			414
Madison, Wis.	{Marvin		43 05 N.	89 23 W.	974
	{Callendar	Callendar			1,009
Lincoln, Nebr.	{Marvin		40 50 N.	96 41 W.	1,225
	{Callendar	Callendar			1,250
Chicago, Ill.	Eppley	Engelhard	41 47 N.	87 35 W.	688
New York, N. Y.	do	do	40 46 N.	73 58 W.	156
Fresno, Calif.	do	do	36 43 N.	119 49 W.	330
Pittsburgh, Pa.	do	do	40 32 N.	80 02 W.	1,114
Fairbanks, Alaska	do	do	64 52 N.	147 39 W.	500
Twin Falls, Idaho.	do	do	42 29 N.	114 25 W.	4,300
La Jolla, Calif.	Weather Bureau	do	32 50 N.	117 15 W.	85
Miami, Fla.	Callendar	Callendar	25 41 N.	80 12 W.	------
Gainesville, Fla.	Moll	Richard	29 39 N.	84 21 W.	233
New Orleans, La.	Eppley	do	29 56 N.	90 07 W.	100

Beginning with February, 1932, measurements of the intensity of direct solar radiation have been obtained through the red and yellow glass screens recommended by the Commission on Solar Radiation of the International Geodetic and Geophysical Union at its conference at Berlin and Potsdam, February 23–26, 1931.[1]

The screens were obtained through Doctor Süring, director of the Potsdam Magnetic-Meteorological Observatory. A Weather Bureau thermoelectric pyrheliometer, exposed in a Marvin pyrheliometer mounting, with the two glass screens taking the place of the blades of the shutter at the outer end of a diaphragmed tube, is employed in the measurements.

The equatorial clock-driven mounting keeps the tube pointed quite accurately towards the sun, but hand adjustment is frequently made. The electrical mechanism designed to rotate the shutter a quarter turn each minute is operated by hand at such time intervals as are desired, usually about 10 minutes, to successively measure the current when there is no screen between the pyrheliometer and the sun, and when the yellow and the red screens are alternately interposed. At the same time a Marvin pyrheliometer, exposed near the thermoelectric pyrheliometer, is continuously read.

The thermoelectric pyrheliometer at present records on a Leeds and Northrup recording potentiometer, and a comparison of the record obtained when no screen is interposed with synchronous readings of the Marvin pyrheliometer makes it possible to reduce millivolts of current generated in the thermopile of the pyrheliometer to gram calories per minute per square centimeter of radiation intensity. In the thermopile in use a radiation intensity of one gram calorie per minute per square centimeter generates a current having an e. m. f. of about 7.20 millivolts.

[1] Kimball, Herbert H. The radiation conference at Berlin and Potsdam, Feb. 23–26, 1931. Mo. Wea. Rev., May, 1931, Vol. 59, pp. 187–188.

The first measurements with the screens will be summarized in the February number of the REVIEW.

Table 1 shows that solar radiation intensities measured at normal incidence were above the normal intensity for January at Washington, slightly below the January normal at Madison and at Lincoln in the morning, but above the normal at Lincoln in the afternoon. The depression in intensities at Lincoln during the morning hours was undoubtedly due to smoke, which was carried away by the wind later in the day.

Table 2 shows a deficiency in the total solar radiation received on a horizontal surface at all stations for which normals have been computed except at Miami, Fla., Fresno and La Jolla, Calif., where an excess was recorded.

No skylight polarization measurements were made at Madison, Wis., as there was a trace of snow on the ground during most of the month, which produces a disturbing effect. At Washington, measurements made on three days give a mean of 62 per cent with a maximum of 66 per cent on the 18th. These are slightly above the respective averages for Washington in January.

TABLE 1.—*Solar radiation intensities during January, 1932*

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Washington, D. C.											
Jan. 2	5.79		0.79	1.01							5.16
Jan. 11	3.30	0.40									3.45
Jan. 14	8.18	0.86	0.99	1.14	1.20						9.47
Jan. 18	3.30						1.30	1.15			3.30
Jan. 20	3.15			1.12	1.28			1.11	0.95	0.81	3.63
Jan. 25	2.49	0.85	0.96	1.14	1.38		1.30	1.11	0.99	0.85	2.49
Jan. 27	5.36			1.10			1.30	1.15	1.01	0.90	3.45
Means		0.70	0.91	1.10	1.29		1.30	1.13	0.98	0.85	
Departures		−0.03	+0.06	+0.09	+0.06		+0.07	+0.09	+0.09	+0.05	
Madison, Wis.											
Jan. 18	2.36							1.20	1.06		2.36
Jan. 20	3.99		0.74	0.82							3.81
Jan. 25	2.36		1.00	1.16	1.31			1.08			2.87
Jan. 27	3.15						1.42	1.29			2.06
Means			(0.87)	(0.99)	(1.31)		(1.42)	1.19	(1.06)		
Departures			−0.17	−0.21	−0.02			−0.01	±0.00		
Lincoln Nebr.											
Jan. 8	1.52							1.26	1.16	1.07	1.52
Jan. 17	1.78							1.23	1.07	1.00	2.74
Jan. 18	1.68	0.76	1.05	1.18				1.22	1.07	0.95	2.16
Jan. 19	3.45							1.15	1.00	0.83	4.57
Jan. 23	2.49	1.00	1.12	1.25	1.41	1.60		1.27	1.16	1.06	2.16
Jan. 25	1.78	0.97	1.00								2.87
Jan. 27	1.68	0.63	0.81	1.04	1.32			1.12	0.95		3.30
Jan. 28	2.49							1.07	0.95	0.85	2.16
Jan. 29	1.02	1.11	1.22				1.48	1.34	1.20	1.14	0.74
Means		0.89	1.04	1.16	(1.36)	(1.60)	(1.48)	1.21	1.07	0.99	
Departures		−0.04	−0.01	−0.02	−0.01		+0.14	+0.04	+0.02	+0.06	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct + diffuse) received on a horizontal surface*

[Gram-calories per day per square centimeter

Week, beginning	Washington	Madison	Lincoln	Chicago	New York	Fresno	Pittsburgh	Fairbanks	Twin Falls	La Jolla	Gainesville	Miami	New Orleans
	Average daily totals												
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 1	89	59	120	41	50	217	70	4.5	113	272	240	324	74
Jan. 8	143	69	161	69	95	143	131	5.8	155	248	263	324	148
Jan. 15	178	116	188	89	118	210	99	5.3	146	274	223	331	236
Jan. 22	163	155	237	139	120	269	75	26.9	223	318	----	397	171
	Departures from weekly normals												
Jan. 1	−61	−72	−60	−37	−52	+65	−22	----	−57	+37	−24	+26	----
Jan. 8	−10	−71	−29	−12	−7	−19	+33	----	−29	+12	+18	+29	----
Jan. 15	+18	−43	−12	−6	+5	+20	−10	----	−50	+31	−16	+39	----
Jan. 22	−15	−31	+13	+30	−14	+54	−40	----	+33	+66	----	+85	----
	Accumulated departures on Jan. 28												
	−476	−1,519	−616	−175	−476	+840	−273	----	−271	+1,022	----	+1,253	----

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic: Diff. long.	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day
1932	*H m*	°	°	°			
Jan. 1 (Naval Observatory)	11 41	+26.0	243.2	−13.0	108	-------	108
Jan. 2 (Naval Observatory)	10 38	−17.0	187.6	+4.5	-------	31	------
		+38.5	243.1	−13.0	123	-------	154
Jan. 3 (Mount Wilson)	11 15	−70.0	121.1	+11.0	9	-------	------
		−4.0	187.1	+4.0	-------	10	------
		+50.0	241.1	−13.0	107	-------	126
Jan. 4 (Mount Wilson)	17 10	−55.0	119.6	+11.0	-------	6	------
		+69.0	243.6	−14.0	152	-------	158
Jan. 5 (Mount Wilson)	11 0	+80.0	244.9	−14.0	218	-------	218
Jan. 6 (Mount Wilson)	11 30	−30.0	121.6	+13.0	-------	8	8
Jan. 7 (Yerkes Observatory)	12 54	No spots			-------	-------	------
Jan. 8 (Perkins Observatory)	11 45	No spots			-------	-------	------
Jan. 9 (Perkins Observatory)	10 30	No spots			-------	-------	------
Jan. 10 (Naval Observatory)	10 25	No spots			-------	-------	------
Jan. 11 (Naval Observatory)	10 28	No spots			-------	-------	------
Jan. 12 (Naval Observatory)	12 16	No spots			-------	-------	------
Jan. 13 (Naval Observatory)	12 53	No spots			-------	-------	------
Jan. 14 (Naval Observatory)	10 38	No spots			-------	-------	------
Jan. 15 (Naval Observatory)	10 33	+13.0	46.5	−8.5	-------	31	31
Jan. 16 (Naval Observatory)	11 10	+27.0	47.0	−8.0	-------	108	108
Jan. 17 (Yerkes Observatory)	12 15	+38.4	44.6	−9.6	6	-------	------
		+38.9	45.1	−9.2	6	-------	------
		+40.2	46.4	−6.5	6	-------	------
		+43.6	49.8	−10.4	30	-------	48
Jan. 18 (Naval Observatory)	10 38	+57.0	50.9	−9.5	25	-------	25
Jan. 19 (Naval Observatory)	11 13	+69.0	49.4	−10.0	9	-------	9
Jan. 20 (Naval Observatory)	11 6	No spots			-------	-------	------
Jan. 21 (Naval Observatory)	12 3	−72.0	241.6	−12.0	81	-------	81
Jan. 22 (Mount Wilson)	11 25	−60.0	240.7	−14.0	-------	127	------
		+36.0	336.7	+16.0	-------	13	140
Jan. 23 (Yerkes Observatory)	14 59	−44.6	241.1	−13.3	138	-------	------
		−41.8	243.9	−13.6	3	-------	------
		+54.4	340.1	+14.8	28	-------	169
Jan. 24 (Naval Observatory)	13 35	−33.0	240.3	−12.0	108	-------	108
Jan. 25 (Naval Observatory)	10 32	−21.5	240.3	−13.0	53	-------	------
		+27.0	288.8	−6.0	-------	37	90